Claims

1. (Currently amended) A method comprising monitoring a fermentation process of a population of cells in a ~~fluid medium~~ suspension or slurry by detecting ultrasound backscattered from the cells in the ~~medium~~ suspension or slurry.

2. (Currently amended) The method of claim 1 further comprising substantially contemporaneously measuring the ultrasonic attenuation of the cells and the ~~medium~~ suspension or slurry.

3. (Currently amended) The method of claim 2 wherein ~~a common~~ an ultrasonic interrogation device is used to measure the ultrasonic attenuation and to detect the backscattered ultrasound.

4. (Currently amended) The method of claim 3 wherein the ~~common~~ ultrasonic interrogation device includes a transducer positioned to transmit ultrasound towards a reflecting surface, wherein the transducer receives ultrasound which reflects from the reflecting surface, and wherein the transducer receives ultrasound which backscatters from cells that are positioned between the transducer and the reflecting surface.

5. (Original) The method of claim 1 wherein a transition in the growth phase of the cells is determined based on backscattering as a function of time.

6. (Original) The method of claim 5 wherein the transition is from a logarithmic growth phase to a stationary growth phase.

7. (Original) The method of claim 1 wherein the cells are bacteria.

8. (Original) The method of claim 1 wherein the cells are yeast cells.

9. (Currently amended) The method of claim 1 further comprising interrogating the cells in the ~~medium~~ suspension or slurry with ultrasound from a focused transducer to produce the backscattered ultrasound.

10. (Original) The method of claim 9 wherein the focused transducer defines a focal length and the detected ultrasound backscatters from cells spaced from the transducer a distance between about 50% and 150% of the focal length.

11. (Original) The method of claim 1 further comprising calculating an attenuation corrected backscattering amplitude by multiplying a measured backscattering amplitude by a correction factor, wherein the correction factor is a function of a value corresponding to attenuation times distance.

12. (Original) A method comprising monitoring fermentation occurring in a fermentor by detecting ultrasound backscattered from cells in a fermentation broth as a function of time, wherein the detecting is with a transducer positioned inside the fermentor.

13. (Original) The method of claim 12 further comprising determining a cell growth phase transition based on the detected ultrasound as a function of time.

14. (Original) The method of claim 12 wherein detecting the ultrasound backscattered from the cells includes determining amplitude of waveforms in a predetermined time gate.

15. (Original) The method of claim 14 wherein the amplitude is a Fourier amplitude.

16. (Original) The method of claim 14 wherein the cells are interrogated with ultrasound from a transducer having a focal length and wherein the time gate substantially corresponds to backscattering from cells spaced from the transducer a distance between about 50% and 150% of

the focal length.

17. (Currently amended) A system comprising:

a ~~fermentor~~ fermenter and a fermentation monitoring system comprising an ultrasonic transducer and a processing device~~;~~;

wherein the transducer has a face inside the ~~fermentor~~ fermenter such that the contents of the ~~fermentor~~ fermenter are free-flowing around the face of the transducer; and

wherein the monitoring system is operable to determine ultrasonic backscattering from the contents of the fermenter as a function of fermentation time.

18. (Original) The system of claim 17 wherein the monitoring system determines backscattering at a predetermined distance from the transducer face.

19. (Original) The system of claim 18 wherein the transducer has a focal length and the predetermined distance is between 50% and 150% of the focal length.

20. (Currently amended) The system of claim 17 wherein the processing device is a computer containing programming instructions for determining a transition between growth phases of cells in the ~~fermentor~~ fermenter based on changes in the backscattering as a function of time.

21. (Original) The system of claim 20 wherein the programming instructions include correcting a measured backscattering response for attenuation effects.

22. (Original) The system of claim 21 wherein the correcting involves multiplication by a function of a value representing attenuation times distance.

23. (Original) A method comprising determining cell growth during fermentation by monitoring ultrasound backscattered from the cells as a function of time.

24. (Currently amended) The method of claim 23 wherein the monitoring is with a transducer positioned inside the ~~fermentor~~ fermenter containing the cells and wherein the transducer operates in pulse-echo mode to detect the ultrasound backscattered from the cells.

25. (Original) A method comprising monitoring cell size and number per volume during fermentation by monitoring ultrasound backscattered from the cells as a function of time.